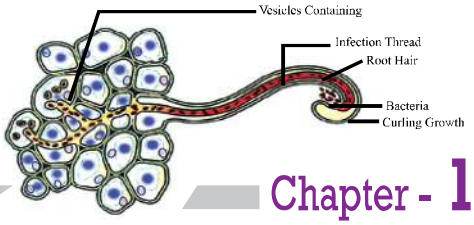


Chapter - 12

Mineral Nutrition

Points To Remember

Autotroph : An organism that sythesize its required nutrients from simple and inorganic substance; Example—plants, blue green algae (cyanobacteria)

Heterotroph : An organism that cannot synthesise its own nutrients and depend on others. Example—Bacteria, protists, members of animalia.

Biological nitrogen fixation: Conversion of atmospheric nitrogen into organic compounds by living organisms.

Nitrification : Conversion of ammonia (NH_3) into nitrite and then to nitrate.

Denitrification : A process of conversion of nitrate into nitrous oxide and nitrogen gas (N_2).

Leg-hemoglobin : Pinkish pigment found in the root nodules of legumes. It acts as oxygen scavenger and protects the nitrogenase enzyme from oxidation.

Flux : The movement of ions is called flux. Influx is inward movement of ions into the cells and efflux is the outward movement of ions.

Inhibition of cell division : Deficiency of N, K, S. and Mo.

Necrosis : Death of tissues particularly leaf tissue due to deficiency of Ca, Mg, Cu, K.

Delayed Flowering : due to deficiency of N, S, Mo.

Mineral Nutrition : Plants require mineral elements for their growth and development. The utilization of various absorbed ions by a plant for growth and development is called mineral nutrition of the plant.

Hydroponics : Soil-less culture of plants, where roots are immersed in nutrient solution (without soil) is called hydroponics. The result obtained from hydroponics may be used to determine deficiency symptoms of essential elements.

Essential Elements

Macronutnents	Micro-nutrients
Macronutrients are present in plant tissues in concentrations of more than 10 mole Kg^{-1} of dry matter. C, H, O, N, P, K, S, Ca, Mg	Micro-nutrients are needed in very low amounts : less than 10 m mole Kg^{-1} matter. Fe, Mn, Cu, Mo, Zn, B, Cl, Ni

In addition to the 17 essential elements, Na, Si, Co and Si are required by some higher plants.

Criteria for essentiality :

1. The element must be necessary for supporting normal growth and reproduction.
2. Requirement must be specific and not replaceable by another element.
3. The element must be directly involved in the metabolism of the plant.

Chlorosis : Yellowing of leaves due to loss of chlorophyll.

Active Transport : Absorption occuring at the expense of metabolic energy.

Passive Transport : Absorption of minerals with concentration gradient by the process of diffusion without the expense of metabolic energy.

Role of Minerals Elements in Plants
MACRO NUTRIENTS

Element	Obtained as	Functions	Deficiency symptoms
Nitrogen (N)	Mainly as NO_3^- some as NO_2^- or NO_4^-	Constituent of proteins, nucleic acids, vitamins and hormones.	Stunted growth Chlorosis, dormancy of causal buds.
Phosphorus (P)	Phosphate ions ($H_2PO_4^-$ or HPO_4^{2-}).	Constituent of cell membrane. Required for the synthesis of nucleic acids, nucleotides, ATP NAD and NADP for phosphory-lation reactions.	Poor growth of plant. Leaves dull green, delay in seed germination purple or red spots on leaves, premature leaf fall.

Potasium (K)	K^+	Helps to maintain an anion-cation balance in cells. Involved in protein synthesis, in opening and closing of stomata; activation of enzymes; mainte-nance of turgidity of cells.	Stunted growth; yellow leaves edges of leaves; mottled appearance of leaves. Premature death.
Calcium (Ca)	Ca^{2+}	Required in formation of mitotic spindle; involved in normal functioning of cell membranes; activates certain enzymes; as calcium pectate in middle lamella of the cell wall.	Stunted growth, chlorosis of young leaves.
Magnesium (Mg)	Mg^{2+}	Activates enzymes in phosphate metabolism, constituent of chlorophyll; maintains ribosome structure.	Chlorosis between the leaf veins necroticon purple colours spots on older leave
Sulphur (S)	SO_4^{2-}	Constituent of two amino-acids-Crysteine and methionine and proteins, coenzymes, vitamins and ferredoxin.	Chlorosis of younger leaves, stunted growth

MACRO NUTRIENTS

Element	Obtained as	Functions	Deficiency symptoms
Iron (Fe)	Fe^{3+}	Constituent of Ferredoxin and cytochrome; needed for synthesis of chlorophyll.	Chlorosis of leaves
Manganese (Mn)	Mn^{2+}	Activates certain enzymes involved in photosynthesis, respiration and nitrogen metabolism.	Chlorosis, grey spots on leaves.

Zinc (Zn)	Zn^{2+}	Activates various enzymes like carboxylases. Required for synthesis of auxins.	Malformation of leaves
Copper (Cu)	Cu^{2+}	Activates certain enzymes. Essential for overall metabolism	Stunted growth, inter-veinal chlorosis in leaves. Necrosis of the tip of young leaves, die back of shoot.
Boron (B)	BO_3^{3-}, $B_4O_7^{2-}$	Required for uptake of water and Ca, for membrane functioning, pollen germination, cell elongation carbohydrate translocation.	Death of stem and root apex, loss of a foical dominance, abscission of flowers, small size of fruits
Molybdenum (Mo)	MoO_2^{2+} (molybdate ions)	Activates certain metabolism.	Nitrogen deficiency inter-veinal chlorosis retardation of growth
Chlorine (Cl)	Cl^-	Maintains solute concentration along with Na+ & K+; maintain anion-cation balance in cells; essential for oxygen evolution in photosynthesis.	Wilted leaves; stunted root growth and reduced fruiting.

Critical Concentration : The concentration of the essential element below which plant growth is retarted. The element is said to be deficient when present below the critical concentration.

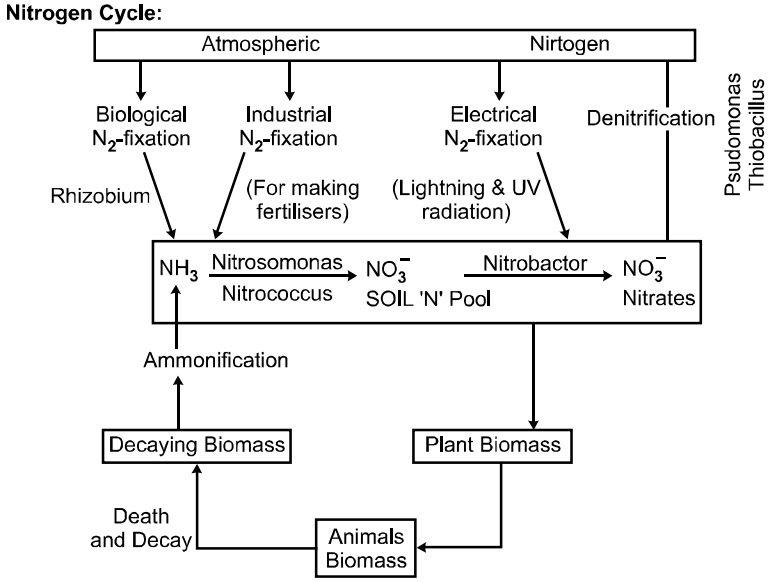
Deficiency symptoms : Chlorosis, stunted growth, premature fall of leaves and buds and inhibition of cell division.

Toxicity of micronutrient : Any mineral ion concentration in tissues that reduces the dry weight of tissues by 10% is considered toxic. Toxicity of one element may lead to deficiency of other element since the former may inhibit the uptake of latter., e.g., Mn competes with Fe, Mg for uptake and also inhibits Ca translocation to shoot apex. Therefore Mn toxicity symptoms are actually same as deficiency symptoms of Fe, Mg and Ca.

Role of microbes in nitrogen cycle :

- *Rhizobium, Azotobacter, Rhodospirillum;* Fix atmospheric nitrogen
- *Nitrosomonas and/or Nitrococcus* :—Conversion of ammonia to nitrite
- *Nitrobacter :* Conversion of nitrite into nitrate.
- *Pseudomonas* and *Thiobacillus* : reduce nitrate into nitrogen.

Nitrogen Cycle:



Nitrogen Cycle

Nitrogen fixation—The process of conversion of Nitrogen (N_2) into ammonia (NH_3).

Ammonification—The process of decomposition of organic nitrogen of plants and animals (proteins) into ammonia.

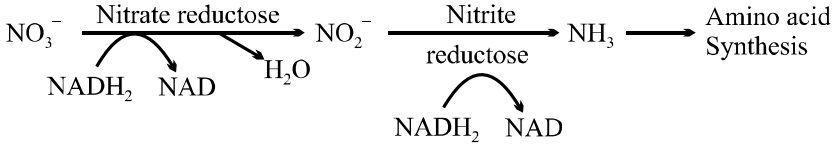
$$\text{Dead Plants and Animals} \xrightarrow[\text{Bacteria}]{\text{Ammonifying}} NH_3$$

Nitrification—The ammonia so formed may volatilise and re-enter the atmosphere, or some of the ammonia may be converted into nitrate by soil bacteria

$$2NH_3 + 3O_2 \xrightarrow{\text{Nitrosomonas}} 2NO_2^- + 2H_2O + 2H^+$$

$$2NO_2^- + O_2 \xrightarrow{\text{Nitrobactor}} 2NO_3^-$$

The Nitrate so formed can be easily absorbed by the plants and transported to leaves. In leaves, nitrate is reduced to ammonia to form amino-acids, because nitrate can not used by plants as such.



Denitrification—Process of reduction of the nitrate present in soil to nitrogen. It is carried out by bacteria like *Pseudomonas* and Thiobacillus.

Biological Nitrogen Fixation—Reduction of nitrogen to ammonia by living organisms. Certain prokaryotes are able to fix nitrogen because of presence of 'nitrogenase' enzyme in them.

Nitrogen fixing microbes may be

(a) Free living—(i) Aerobic—*Azotobacter*
(ii) Anaerobic—*Rhodospirillum*
(b) Cyanobacteria—*Nastoc, Anabaena*
(c) Symbiotic—(i) With leguminous plants—*Rhizobium*
(ii) With non-leguminous plants—*Frankia*

Enzyme nitrogenase—The enzyme nitrogenase is Mo-Fe protein and catalysis the conversion of atmospheric nitrogen to ammonia (First stable product of nitrogen fixation)

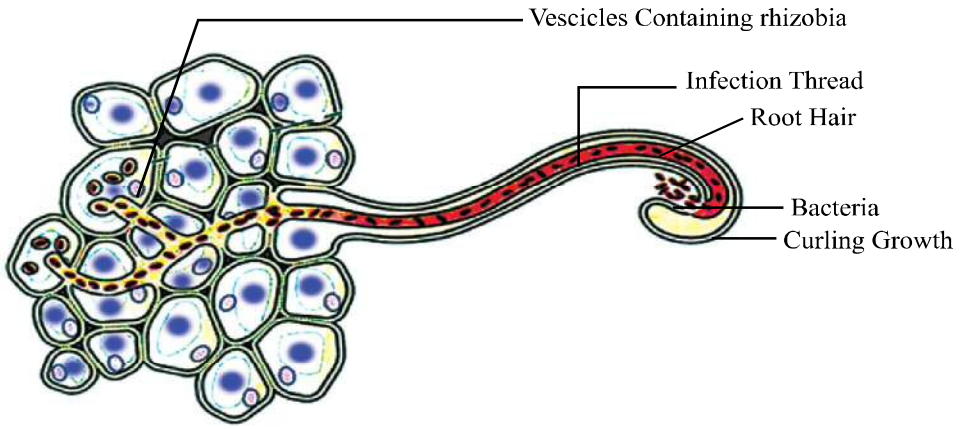
Leg-hemoglobin—A pink colour pigment, similar to hemoglobin of vertebrates and functions as an oxygen scavenger and protects nitrogenase from oxygen.

$$N_2 + 8e^+ + 8H^+ \ 16ATP \text{ dinitrogenase } 2NH_3 + H_2 + 16\ ADP + 16\ Pi$$
$$\longrightarrow$$

Steps of nodule formation :

(a) *Rhizobium* bacteria present in soil contract a susceptible root hair.
(b) Infection of the root hair cause it to curve and deformed due to chemical secretion.
(c) An infection thread is produced carrying the bacteria into the cortex of the root.
(d) The bacteria get modified into rod-shaped bacteria and cause inner cortical and pericycle cells to divide plant produce cytokinin and auxin to stimulate cell division and enlarge to form nodules.

(e) Division and growth of cortical and pericycle cells lead to nodule formation.



Nodule Formation in Roots of Leguminous Plants

(Refer Figure 12.4 page 203 NCERT Text Book)

Mechanisms of N_2 fixation

It require 3 components—

(a) A strong reducing agent like $FADH_2$, $NADPH_2$
(b) Nitrogenase enzyme
(c) ATP (as energy service)

Steps

(a) Formation of Diamide
(b) Formation of Hydrazine (N_2H_4)
(c) Formation of Ammonia,
See Fig. 12.5 Page 203 NCERT

Questions

Very Short Answer Questions (1 mark each)

1. Name one symbiotic nitrogen-fixing bacteria.
2. Give two examples of photosynthetic microorganisms, which also fix atmospheric nitrogen.
3. Name two organisms each which fix nitrogen *symbiotically* and symbiotically.
4. Which substance impart pink colour to the root nodule of a leguminous plant and also mention its role ?

5. What is the term used for mineral deficiency symptom in plants in which leaves become yellow in different pattern ?
6. Define hydroponics.
7. Give the name of an insectivores angiosperm plant.
8. Give the name of one non-symbiotic nitrogen fixing prokaryote.
9. Name the green house gas produced in rice fields.

Short Answer Questions-I (2 marks each)

10. Differentiate between two types of absorption of minerals in plants from soil.
11. Name the following :
    (a) Bacteria which converts ammonia into nitrite.
    (b) Bacteria which oxidises nitrite into nitrate.
12. How does Leghemoglobin protect the enzyme nitrogenase ?
13. Name the enzyme found in root modules for N_2 fixation ? Name the pink coloured pigment required for its functioning.

Short Answer Questions-II (3 marks each)

14. Write the deficiency symptoms of the following three elements :
    (a) Phosphorus
    (b) Magnesium
    (c) Potassium
15. Describe the following three deficiency symptoms and co-relate them with concerned mineral deficiency :
    (a) Phosphorus
    (b) Magnesium
    (c) Potassium
16. Explain in brief the steps involved in biological nitrogen fixation.
17. Describe the two main processes of synthesis of amino acids from Ammonium ion (NH_4^+) in plants.

18. Define critical concentration, also mention four deficiency symptoms of nutrients in plants.
19. Write a short note on toxicity of micronutrient. Give an example which show toxicity of one element may lead to deficiency of other element.

Long Answers (5 marks each)

20. Describe all the steps of nitrogen cycle in nature.
21. Describe with diagrams how root nodules are formed in leguminous plants.
22. Explain adaptations in leguminous root nodules for N_2 fixation.

Answers

Very Short Answers (1 mark each)

1. *Rhizobium*
2. *Anabaena, Nostoc*
3. **Asymbiotically-***Azotobacter, Bacillus polymyxa* **Symbiotically-***Rhizobium, Anabaena.*
4. Leghemoglobin. It is an oxygen scavenger, which protects the enzyme nitrogenase.
5. Necrosis.
6. The technique of growing plants in a nutrient solution without soil is called hydroponics.
7. *Nepenthes* (Pitcher plant)
8. *Azotobacter*
9. Methane (CH_4)

Short Answers-I (2 marks each)

10. Refer to NCERT Book, Page no. 200 (12.3).
11. (i) Nitrifying Bacteria—*Nitrosomonas*.
    (ii) Nitrifying Bacteria—*Nitrobacter*
12. Refer to page no. 203.
13. Enzyme-Nitrogenase
    Pink coloured pigment-Leghaemoglobin

Short Answers-II (3 marks each)

14. Refer to 'Points to Remember'.
15. Refer to 'Points to Remember'.
16. Refer to 'Points to Remember'.
17. Refer to 'Points to Remember' (Fate of Ammonia)
18. Refer to 'Points to Remember'.
19. Refer to 'Points to Remember'.

Long Answers (5 marks each)

20. Refer to 'Points to Remember'.
21. Refer to 'Points to Remember'.
22. Refer to NCERT Book Page No. 203.